

## Notes on *Aphrocallistes beatrix* Gray, particularly with reference to the form occurring in East Asiatic seas.

By

Isao Ijima, *Ph. D.*

In the "Valdivia" Report, F. E. Schulze ('04, pp. 146, 147) has ably pointed out that *Aphrocallistes beatrix* Gray '58, *A. bocagei* Wright '70 and *A. ramosus* F. E. Schulze '87 are not specifically separable, but represent one species which should go by the oldest name of *A. beatrix*. The same author further remarked to the effect that Topent's *A. azoricus* (Tops. '01 p. 455 ; '04, p. 48), if this really be an *Aphrocallistes*, may possibly belong within the range of *A. beatrix*. I entirely concur with him in the above opinion. *A. beatrix* is then to be considered as an exceedingly variable species, widely distributed in the Pacific, Indian and Atlantic Oceans. Now, from my studies I have come to entertain the idea that that species, as it occurs along the Japanese coasts and in more southern seas of the Western Pacific,—i.e. the same form of *Aphrocallistes* which F. E. Schulze ('87, Chall. Rep.) had erstwhile referred in part to *A. bocagei* Wright and in part made into his *A. ramosus*,—is characterized by certain common and fairly constant features by which it may be distinguished in a way from the form or forms occurring in other parts of the world, though the differentiation can be of no more taxonomic significance than varietal or subspecific. For the sake of convenience I will refer to the form of the East Asiatic seas by the name of *A. beatrix orientalis*.

Now, the following is a summary account of the form just mentioned, coupled with remarks in comparison with what is known of specimens from

some other parts of the world. It should be noted that the descriptions in this paper refer in particular to *A. beatrix orientalis*, unless otherwise referred to in special. The notes were drawn up with the view of creating a basis of comparison to be utilized in my forthcoming report on the hexactinellids collected by the "Siboga" in the Malayan seas. It may as well be mentioned here that, of the rich material of *A. beatrix orientalis* collected by me in the Sagami Sea, I have subjected more than a dozen different stocks to specially close studies for the purpose of determining the range of individual variations. Further stood at my disposal some specimens of the same form from the Suruga Bay, the Gulf of Kagoshima, the China Sea and the Philippine Islands.

In general habitus the oriental form exhibits the same extensive range of variation as is ascribed to the entire species. What may be considered as an individual is either an irregular, dichotomously branching, simple tube ("ramosa" type), or consists of an erect axial calyx bearing a number of radial tubo-branches at different heights between the base and the upper end. The tubes, be these parts of individuals of the "ramosa" type or branches of axial calyx, measure generally 4–8 mm. in diameter, seldom reaching up to 10 mm. The calyx may reach 80 mm. or thereabout in height, more or less widening superiorly up to 25 mm. or more across. The wall, irrespective of the configuration of the parts it belongs to, is generally from 0.6 mm. to nearly 1 mm., seldom up to 1.4 mm., thick. The honeycomb-like radial canals of the wall skeleton measure 0.6–0.8 mm. in diameter. It is unnecessary to go into further details of the macroscopic structure, as this agrees in all essential points with what is already known of it. Only it should be pointed out that, as regards the dimensions of parts, the oriental specimens fall considerably short of the maximum attained by some of the Indomalayan specimens, in which the ramose tubes are frequently nearly as thick as one's finger, the wall fully 2 mm. thick or even thicker, and the radial canals 1 mm. or more wide.

Dictyonal beams of the skeleton vary in different individuals from being only sparsely tubercled and at places quite smooth to being profusely

tubercled throughout. This may be due in a measure to the age of the sponge, as was pointed out by F. E. Schulze. The intercanalar dictyonal septa, in the parts between the radial lines of their junction with one another, are thin, but not quite flat and even. In them the dictyonal beams do not run all in the same plane, nor always in a single regular tier as seen in sections; so that, the septa in sections present an appearance more like that of a thin sheet of an irregular three-dimensional framework than of a single-layered network evenly spread out. This stands somewhat at variance with the evenly complanated state of the septal dictyonalia as figured by F. E. Schultze ('04, pl. XI. fig. 2) from a specimen taken in Siberut Strait on the SW. coast of Sumatra, or as I myself have found in many of the Malayan specimens collected by the Siboga. The dictyonal nodes are but slightly or not at all swollen.

The rough spikes growing out from both dermal and gastral edges of intercanalar septa vary much in their development according to individuals. Spikes on the surface of the septa are of but exceptional occurrence,—another fact which seems to be noteworthy in view of their apparently frequent and numerous presence in that position—all pointed towards the external opening of the canals—in Malayan as well as Indoceanic specimens.

Free oxyhexactins occur in very varying numbers. In the oriental form I find them to fluctuate from  $50\mu$  to  $100\mu$  in length of rays. The rays are rough, but scarcely ever distinctly spiny.

The uncinates offer no important points of characterization which might likely be utilized for the differential purpose within the species. The same may be said of the rough diactine gastralialia (up to 1.4 mm. long in the oriental form).

The dermalia exhibit some points which seem worth while to call attention to. In the oriental form they are both pentactins and hexactins, of which the latter have the distal ray in various stages of development towards acquiring a plumose character (hexactine pinules). In some of the specimens the hexactine dermalia are decidedly rare, while in others they

are well in evidence, though not in numerical predominance over the pentactins. In other words, the dermalia are generally mostly pentactine. Irrespective of their being pentactine or hexactine, the dermalia measure in the length of tangential rays from about  $80\mu$  up to  $120\mu$ ,  $150\mu$ ,  $175\mu$ ,  $230\mu$  or even  $290\mu$  in different individuals, the proximal ray being about as long as, or either somewhat longer or shorter than, the tangentials of the same spicule. In a single case (Sc. Coll. sp. No. 279) of Sagami Sea specimens, certain large pentactine dermalia, amongst others of much smaller dimensions, were found to possess exceptionally long proximal ray, which, measuring fully  $600\mu$  in length, extended nearly right through the entire thickness of the sponge wall.

In pentactine dermalia there usually exists a low swelling or a knot in place of the atrophied distal ray. In some other dermalia the knob is prolonged to a short stumpy peg, and in still others this may be slightly swollen towards the outer end and may here bear a few short spiny processes. The last condition leads over to those cases of hexactine dermalia in which the distal ray has, so to say, fairly started on the way of assuming, but has not yet quite reached, a plumose state of development, and on that account may well be designated subplumose. In some of the specimens the subplumose distal ray never exceeds  $80\mu$  or even half that in length, thus presenting quite a stunted appearance. In still other specimens the same ray is found to reach a length of  $130\mu$ ,  $150\mu$  or even  $185\mu$ ; in these cases the shaft slightly thickens distally, remains smooth or only sparsely tubercled in the proximal half of its length, and then commences to bear short, obliquely distally directed spines, which more distally grow somewhat longer but are neither so long nor numerous as to give to the parts a decidedly feather-like appearance. The above subplumose or imperfectly feather-like state of the distal rays represents about the highest limit of development reached by hexactine dermalia or pinules in the great majority of the specimens. An exception to the rule was found in the single case of a specimen from Kōzushima (Sc. Coll. Sp. No. 552), in which some, but by no means all, of the hexactine

dermalia present exhibited a fairly plumose appearance in the distal parts of their distal rays (up to  $150\mu$  long; breadth of the plumose parts up to  $24\mu$ ; longest lateral spine up to  $16\mu$ ).—To sum up: The dermalia in *A. beatrix orientalis* consist largely of pentactins, with admixture, in variable proportions, of hexactins in which the distal ray may be spineless and simply peg-like, or spined and subplumose, but is rarely quite plumose. The said distal ray seems not to exceed  $185\mu$  in length, generally standing very considerably under that length.

Somewhat a reverse of the above rule as regards the dermalia seems to obtain in specimens from other parts of the world. For the dermalia of these only hexactins were given by authors, indicating either absence or only insignificant presence of any other, but particularly pentactine, form amongst them; and the distal ray of those hexactine dermalia has always been described to be "feather-like," "fir-tree-like" or "poplar-like." Thus, the Atlantic form ("*A. bocagei*") of the species is known to have unequivocally feather-like or fir-tree-like distal rays to dermal hexactins (Carter '73, p. 450, pl. XV. fig. 9.—F. E. Schulze '87, p. 315, pl. LXXXIV. fig. 8). My own observations on a sample, kindly presented to me by Professor F. E. Schulze, from the Mid-Atlantic specimen which was obtained by the "Challenger" (Stat. 344, off Ascension Island) and which was identified by him as *A. bocagei* Wright, have shown that the dermalia in that specimen are predominantly or nearly exclusively well-developed pinular hexactins, as were indeed given to be by him in the Challenger Report. I have found the plumose distal ray to be  $182$ — $231\mu$  long and up to  $40\mu$  broad; the lateral spines up to  $28\mu$  long; tangential rays on an average  $133\mu$  long and the proximal ray always somewhat shorter.—In the type specimen of *A. beatrix* from Malacca the dermalia were described by F. E. Schulze ('87, p. 312) to be hexactins "in which the distal ray bears numerous narrow, curved, fir-tree-like, lateral prickles."—For the Bay of Bengal specimens, collected by the "Investigator" and reported on by F. E. Schulze ('02) as *A. beatrix* Gray, the author describes the dermal hexactins in essentially the same strain, comparing the appearance of their

free distal rays to that of an Italian poplar and giving the length of those rays to be 100—200 $\mu$ .—Finally, among the *Aphrocallistes* brought back by the “Siboga” from the Malayan seas, I have found specimens from certain stations of hers to possess dermalia which are provided with distinctly plumose distal rays, though not always agreeing in details of the appearance of these.—In comparison with the specimens referred to above, the generality of the oriental form of *A. beatrix* in the extended sense may be said to stand markedly backward in the development of the distal ray of dermal hexactins,—not only as a pinular ray simply, but also as regards its absolute dimensions and the numerical proportion of the spicules provided with it in relation to those in which it is entirely or nearly entirely suppressed.

Scopules are present in the sponge wall but on the dermal side only, either in a single form or in two forms. In the former case they are all of a slim appearance and may well be called the leptoscopule; in the latter case there occurs, besides the same leptoscopule, the second form of a thicker and markedly different development, which may be distinguished by calling it the pachyscopule. The constantly occurring leptoscopule is of very variable length (f.i., 230—320 $\mu$ , about 360 $\mu$ , 400—464 $\mu$  long in three different stocks). It is provided with usually 4 (sometimes 3 or 5) terminal branches (60—80 $\mu$ , 75—90 $\mu$ , 88—100 $\mu$  long), which distinctly diverge from the point of their origin and are gently outwardly bent, each terminating with a knob-like or bulb-like swelling. The branches may be somewhat geniculate in the basal parts as was given for “*A. ramosus*” by F.E. Schulze in the Challenger Report, but that state is by no means of general or common occurrence. The terminal swelling is invariably small and is beset with whorls of minute barbs; it never seems to develop into the shape of a moderately large convex disc with toothed margin, as was represented by Carter ('73, pl. xv. fig. 1) from a Portuguese specimen of “*A. bocagei*” or by F.E. Schulze ('02, pl. xv. fig. 2; pl. xvi. fig. 4) from “*A. beatrix*” and “*A. bocagei*” from the Bay of Bengal.

The pachyscopule, which in some specimens does not seem to occur at all, though in some others may take the upper hand over the leptoscopule

in numerical proportion of occurrence, is readily distinguishable from this in having distinctly thicker shaft and terminal branches, which latter usually number four, stand out nearly parallel with one another or diverge but very little, and are scarcely or but indistinctly swollen at the tip. Moreover, both the shaft and the branches are very minutely and fairly uniformly tubercled all over. In length the pachyscopule is about equal to, or somewhat longer than, the leptoscopule in the same stock.

The hexasters are exceedingly variable as regards their characters as well as in number, and in case they occur in more than one distinguishable varieties, in the numerical proportion of these also. The variation refers not only to different stocks, but also in a measure to different parts of one and the same stock. The hexaster varieties to be ascribed to *A. beatrix orientalis* as a whole are both discohexaster and oxyhexaster, each of which may again be divided into a regularly developed ("synstigme") form and an elongate hemihexasterous ("syngamme" form), thus giving in all four varieties of hexasters. Not necessarily all the four occur together in the same stock; but any one or two or even three of them may be found to be missing in spite of careful searches. In twelve Japanese specimens which I have studied with special care as regards their hexasters, the four varieties were found distributed in the manner indicated in the following table.

Number of specimens examined	A Regular discohexaster	B Regular oxyhexaster	C Elongate hemi-discohexaster	D Elongate hemi-oxyhexaster
6	+	+	+	+
2	+	+	○	+
1	+	○	○	+
1	+	○	+	○
1	+	○	○	○
1	○	○	+	○

+ denotes presence, and ○ apparent absence, of the hexaster variety they relate to.

A) From the above table it will be seen that the regular discohexaster is apparently the most constantly occurring variety. In a specimen from Doketsba it constituted the only kind of hexaster to be found and was met with in great abundance. In certain other specimens it was rare, requiring a long search to find one. In one specimen it was missing altogether. The discohexaster in question is a small form between 20 and 50 $\mu$  in diameter, the size fluctuating in the same stock to the extent that the smallest is of about half the diameter of the largest. Each short principal bears 3-5 terminals, which in the smaller examples are quite fine, delicate and minutely capitate, but in the larger ones may be moderately strong and terminate with a small disk bearing a few, not always distinct, recurved claws on the margin. However, in no case of the oriental specimens have I found the claws to be of such a development as might induce one to call the spicule an onychaster, as F. E. Schulze found them to be in some specimens from the Indian Ocean. Usually the terminals are nearly straight and spread out radiatingly from the end of principals; but variation again occurs in this respect, for, in a specimen or two I have found the terminals to each principal form separately a more or less distinctly bell-shaped or perianth-like group. Occasionally the discohexaster in question, but especially the larger examples of it, may be found in the form of a hemidiscohexaster, in which none of the principals are specially elongated.

B) The regular oxyhexaster was met with in many specimens, but again in varying numbers. In only four specimens, out of the twelve, I have found none of it. The oxyhexaster is of much the same appearance as the above regular discohexaster, except of course in the manner of ending of the terminals. Diameter 32-80 $\mu$  (representative fluctuations in different stocks: 32-56 $\mu$ , 35-40 $\mu$ , 56-80 $\mu$ ). Occasionally the oxyhexaster likewise takes the form of a simple hemioxyhexaster.

C) The elongate hemidiscohexaster and D) the elongate hemioxyhexaster often occur together, as do the regular discohexaster and oxyhexaster, in the same stock in varying numerical proportion; but sometimes either of the elongate varieties, and more rarely both of them,



may be missing. Both may measure up to  $80\mu$  in total length, though in some stocks the length seemed not to exceed  $60\mu$ , while in one stock it reached  $76\mu$  as regards C and well up to  $100\mu$  as regards D. In breadth both the varieties are about equal to the diameter of the larger examples of regularly developed and non-elongate hexasters found in the same specimen. It seems the elongate hexasters in the oriental specimens never attain the same large size and the same strength in the development of both shaft and rays as the corresponding spicules in some Indo-Malayan specimens of the species. The figures, given by Carter ('73, pl. iii. fig. 20) and F.E. Schulze ('87, pl. lxxxiv. figs. 9 & 10), of the elongate oxyhexaster from the type specimen of *A. beatrix* Gray (from Malacca) represent that spicule very much larger and more strongly developed than I have ever observed in the oriental form. Also the figures given by F.E. Schulze ('02, pls. xv & xvi) of the same spicule from specimens collected by the "Investigator" in the Bay of Bengal, distinctly indicate the same fact. That author gave for "*A. beatrix*" from that region that the spicule may reach  $150\mu$  in length, a size which I have never yet seen attained by the identical spicule in the oriental form.—In the elongate hemidiscohexas-ter, the terminals end either with a minute pin-head-like swelling or with a small marginally toothed disc, similarly as in the regularly developed discohexas-ter. In the oriental form I have so far not discovered a case which might properly be called an elongate onychaster, such as F.E. Schulze has reported from certain Indoceanic specimens of the species.

There can scarcely be a doubt that the above two varieties of hemi-hexasters (C and D) were derived respectively from the two regular hexasters before noted on (A and B), but particularly from the hemihex-asterous form of these, simply by marked elongation of either one or two opposite principals. The prolonged principal or principals constitute the straight axial shaft (up to  $12\mu$  or  $24\mu$  long), which usually bears at its each end a number (3–5) of terminals in a radiating conical tuft. Rarely the tuft at one end of the shaft is represented by a single terminal standing out in straight line with the shaft. The spicular center lies of course in the shaft,

but either in the middle of its length or nearer to its one end than to the other, according to whether two opposite principals or a single principal have undergone elongation. The four, equally short, lateral principals, arising from the center at right angles to the shaft as well as to one another, are in most cases all uniterminal, each of them with its single terminal presenting the appearance of a simple ray. It is only very seldom that one or more, though probably never all, of the lateral principals are found each with two or three terminals in a radiating group. Sometimes one meets with cases in which the shaft shows terminals at its each end but is apparently without the cruciate lateral rays. However, it will not take long before the observer is convinced of the fact that he has before him a case of hemihexaster, in which only a single principal is prolonged while all the others remain extremely short, and in which the four lateral rays really exist but appear, owing to the proximity of the spicular center to one extremity of the shaft, to constitute a single radiating group of rays in association with the terminals properly belonging to that shaft end.

In conclusion, it may be stated that *A. beatrix orientalis*, subject as it is to very considerable individual variations both as regards its general habitus and the spiculation, on the whole exhibits differentiations in, or tendencies to differentiate toward, the following characters: 1) A somewhat diminutive development of macroscopic body parts, in that the body tubes measure generally only 4–8 mm. and seldom 10 mm. in diameter, the body wall under 1 mm. in thickness, and the radial canals of skeleton 0.6–0.8 mm. in width; 2) Dictyonal septa between radial canals not evenly complanated, a fact which may be correlated with the small caliber of the canals; 3) Spikes on the surfaces of dictyonal septa only occasionally present; 4) Dermalia largely pentactine and in part hexactine, the hexactins with distal rays which are commonly more or less abortively pinular or are of such a rudimentary development as makes the hexactins gradually merge into the pentactins; 5) Leptoscopules with terminal swelling of their branches always small, bulb-like and beset with whorls of minute barbs; and 6) Elongate forms of hemihexasters not over 100 $\mu$  in length.

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